

Using “An Introduction to Structural Methods” - An Interactive DVD-ROM - In and Out of the Classroom: Instructors Supplement

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“An Introduction to Structural Methods” is recommended for use in undergraduate courses in structural geology. This resource supports all aspects of a structural geology syllabus by taking advantage of the medium’s particular strengths in illustration: it is rich in animations, three-dimensional diagrams, photographs, and geologic maps and cross sections. It is not intended to replace conventional textbooks. A detailed Table of Contents of “An Introduction to Structural Methods” is attached, so that the subjects covered and their manner of treatment can be readily reviewed by instructors. Use of the DVD-ROM in and out of the classroom should support mastery of basic skills in structural geology, improve three dimensional thinking and visualization, and teach map reading and map interpretation.

REQUISITE SKILLS: Knowledge of basic rock types and geologic time, and the ability to read and interpret a topographic map are essential for the use of “An Introduction to Structural Methods” and are not included in the DVD-ROM. Later chapters build on concepts covered in earlier chapters. In these cases, reference to the appropriate sections is made and the user is encouraged to review the necessary key concepts.

USING “AN INTRODUCTION TO STRUCTURAL METHODS” IN A STRUCTURAL GEOLOGY COURSE:

Three modules are developed in this supplement to illustrate how “An Introduction to Structural Methods” can be used as (1) a visual aid for an in-class demonstration or lecture presentation; (2) the instructional part of a self-directed lab or homework project; and (3) a student study resource. Additional examples are also provided at the end of each module.

In-Class Demonstration

Many aspects of “An Introduction to Structural Methods” are intended to assist with concepts that have, in the past, been cumbersome or difficult to present in a conventional blackboard-based lecture format. We have tried to anticipate those times when a teacher finds her or himself saying to the class something like: “imagine this flipped on its side” or “then this moves over here”. Now, animations on the DVD-ROM can be projected as a visual aid during lecture. Here, we present down-plunge visualization as an example.

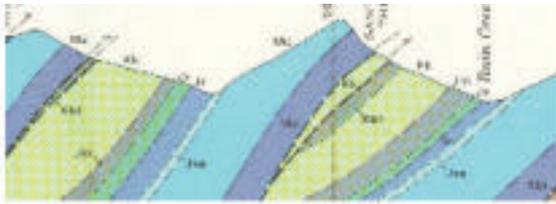
We encourage our students to chant regularly: “the map IS the cross-section...the cross section IS the map”! Our goal with this bit of mysticism is for students to understand structures as three dimensional bodies and to appreciate that a map and a cross section are just two different planar sections through the same three dimensional volume. The most widely taught application of this concept is drawing and visualizing down-plunge projections.

Down plunge viewing is typically linked to teaching about folds (for example, see Chapter 7, Viewing Folds Down Plunge, frames 720-743), but maps and cross sections in thrust belts are also very effective for consolidating this skill while the student becomes more familiar with thrust fault geometry.

Required skills (students can review these skills with sections of the DVD-ROM as noted below):

- finding the plunge of a structure [Chapter 7, Viewing Folds Down Plunge, frames 738-739; Chapter 9, Map Interpretation, frames 914-915]
- the geometric relationship between points on a map and corresponding points projected into a line of section (down-plunge projections) [Chapter 7, Viewing Folds Down Plunge, frame 725 In Depth Comment; Chapter 9, Map Interpretation, frames 910-913]
- elements of thrust faults and thrust belts such as ramps, glides, fault-bend folds, and cut-offs [Chapter 9, Thrust Fault Geometry, frames 845-856]

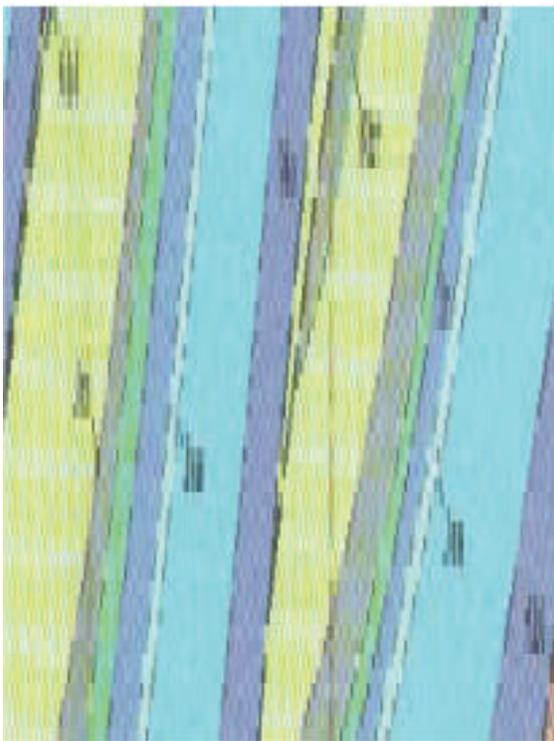
The sequence on maps as down-plunge views of thrust faults seen in cross section starts with an animation of the relationship between map view and cross sectional profile of a simple cylindrical structure, which the viewer can manipulate to see the affect of varying plunge on both map and cross section frame 913). Next, three different cross-sections of thrust faults are each, in turn, elongated (proportional to plunge) and compared to the map pattern of the same structure (frames 916-923). Corresponding elements of each are highlighted for the viewer. The student learns both the concept and technique of down plunge viewing and improves his or her map interpretation of thrust faults. This sequence can be found in frames 916 to 931, Chapter 9. One example is reproduced below:



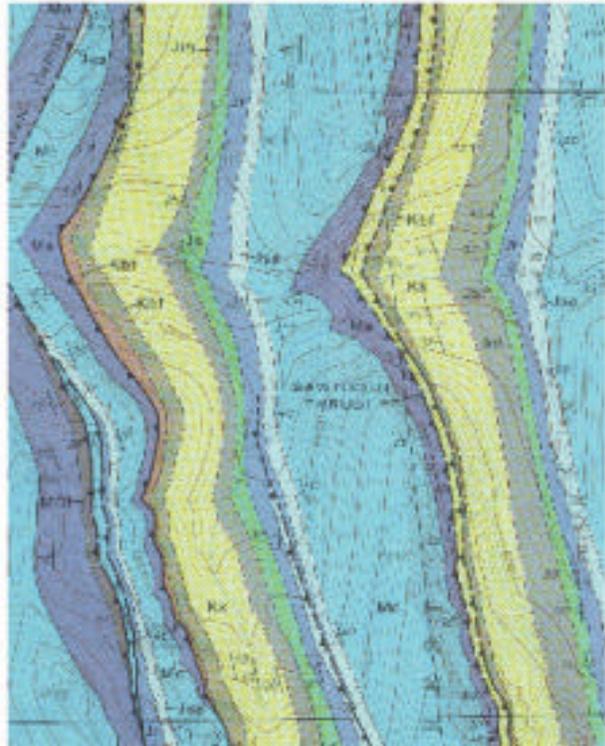
Portion of a cross section
from USGS Map GQ-711



The same cross section with
topography removed



The same cross section (topography
removed) elongated.



A portion of the geologic map (USGS
Map GQ-711) along the line of section for
comparison with the elongated cross section.

Additional examples of illustrations from “An Introduction to Structural Methods” ideal for use as visual aids during in-class demonstrations or lectures:

- The Rule of V's Chapter 2, Understanding Map Patterns: Dipping Planes, frame 86
- Fault offset in map view Chapter 5, Recognizing Faults on Maps, frames 468 and 470
- Cylindrical fold propagation Chapter 7, Fold Elements, frame 673
- Movement of a thrust sheet over ramps and glides Chapter 9, Thrust Fault Geometry, frames 849-850 and 855
- Mohr circle and Coulomb envelope in quartz vein development Chapter 11, The Coulomb Envelope, frame 1148 In-Depth Comment
- Ductile shear zone development Chapter 12, Shear Sense Indicators, frame 1479 (Compare frame 1463)

Student Self-Directed Lab or Homework Exercise

“An Introduction to Structural Methods” is designed to be illustration-rich and text-light but, for all subjects, enough explicit instruction is included that a student can take her or himself through the steps of any technique and learn its application. This allows the DVD-ROM to serve as the instructional introduction to typical homework or lab exercises in a structural geology course. In an exercise constructed in this way, the student can learn how to do the associated exercise at his or her own pace, and go back during the course of the exercise to review steps that prove difficult to master.

Constructing the map pattern of a dipping bed will serve as an example of this type of application. Related topics that will be covered in the course of this exercise are structure contours and three-point problems (determining the strike and dip of a bed from its map pattern).

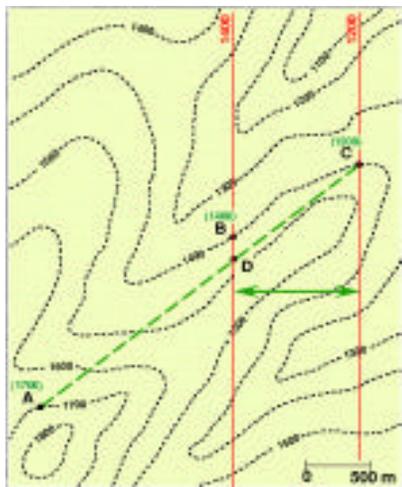
Required skills (required skills are few and can be reviewed with sections of the DVD-ROM as noted below):

- understanding strike and dip of inclined planes [Chapter 1, Orientation of a Plane, frames 32-38]
- the rule of V's [Dipping Planes, frames 83-90]

The technique for constructing the map pattern of a dipping bed from three outcrops of the bed is presented in frames 106 to 172, Chapter 2. The typical exercise that would follow this introduction would provide a simplified topographic base map on which three points of outcrop of a tabular geologic unit are designated. The student would be asked to:

- (1) determine the strike and dip of the unit;
- (2) construct a structure contour map for the unit;
- (3) complete the outcrop pattern for the unit across the map sheet.

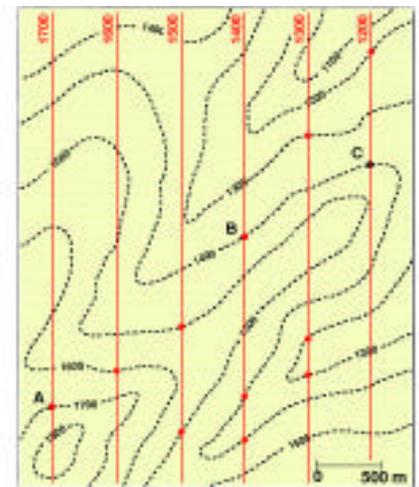
An excellent example of such an exercise can be found as Problem 2-4 in *Structural Analysis and Synthesis A Laboratory Course in Structural Geology* by S.M. Rowland and E.M. Duebendorfer (Blackwell Scientific Publications, 1994, ISBN 0-86542-366-0).



Determining the strike and dip of the bed (three point problem).



Constructing structure contours for the dipping bed.



Plotting the intersection of topo and the structure contours (finding the map pattern).

Additional examples of passages from “An Introduction to Structural Methods” suitable as instructional introductions to student self-directed lab or homework exercises:

- Use of the stereonet in all aspects, for example, plotting the pole to a plane (perhaps in preparation for an exercise on making and interpreting β diagrams) Chapter 3, Plotting Lines and Planes, frames 296-304
- Construction of a geologic cross-section and/or the topographic profile for a cross-section Chapter 4, Cross Section Construction Procedures, frames 395-408
- Using piercing points to determine net slip Chapter 5, Slip Versus Separation, frames 545-566
- Constructing the Coulomb envelope Chapter 11, Mohr Circle and the Coulomb Envelope, frames 1118-1129
- Methods of strain analysis, for example, the Wellman method Chapter 12, Strain Analysis, frames 1367-1374

Student Study Resource

Self-directed study is promoted in “An Introduction to Structural Methods” by the use of interactive quizzes that follow the explication of each key concept. Students can use these quizzes to assess their progress for a given topic and will be prompted by their performance to review fundamentals as needed. An example [Chapter 5, Recognizing Faults on Maps, frame 511] of one such quiz question (answered) is given below.

**Are these normal or reverse faults?
Fault A dips east and fault B dips west.**

A = normal, B = reverse
 A = normal, B = normal
 A = reverse, B = normal
 A = reverse, B = reverse

That's right. Migration of outcrops (the layers dip north) tells us that the footwall moved up relative to the hanging wall for both faults. The block between the two faults moved down relative to the other two blocks and is known as a **graben**.

Is this right? ↪ I give up!

In many quiz questions, once an answer has been selected, the DVD-ROM engages the user in a “dialog” on how the answer should be determined or what makes the right answer right. View frames 511 to 514 on for an example of how this works. Even the “I give up!” or “Need a hint?” buttons are designed to help the student see how to solve the question asked. If they wish to, however, instructors can expand the benefit of some interactive quizzes and/or assess their students’ progress by requiring short written responses in addition to assigning independent study of any given section of the DVD-ROM. For example, if students have been assigned the section in Chapter 12 on shear sense indicators (frames 1462 to 1486, including the quiz in frames 1487 to 1492, the instructor might ask students to write short answers to the following questions: “What geometric relationship or relationships in each picture record the sense of simple shear?” and “Which fabric elements [or components of the structure] correlate to elements of the strain ellipse?”.

Comprehensive list of interactive quizzes in “An Introduction to Structural Methods”

Chapter 1: Elements of Lines and Planes	frames 20, 22, 31, 42, 48-50
Chapter 2: Map Interpretation: Simple Planar Surfaces	frames 73-74, 81, 96-104, 128-134, 150-155, 179-182, 193-196, 214-218
Chapter 3: Stereographic Projection I	frames 235, 242, 273, 290, 310, 343-344, 373-375
Chapter 4: Constructing Geologic Sections	frames 409-412
Chapter 5: Map Interpretation: Faults	frames 457-458, 511-514, 526, 544, 558, 579-581, 594
Chapter 6: Stereographic Projections II	frames 631, 665, 667
Chapter 7: Map Interpretation: Folds	frames 684, 699-703, 716-719, 741-743, 761-765, 782-785
Chapter 8: Map Interpretation: Unconformities, Intrusions	frames 802, 811, 822
Chapter 9: Map Interpretation: Thrust Faults	frames 876-882, 904-907, 933-937
Chapter 10: Fold Analysis	frames 968-970, 991-992, 1002, 1020-1021, 1044-1045
Chapter 11: Stress, Fracture, and Fault Analysis	frames 1086-1089, 1113-1117, 1223-1228, 1156-1160
Chapter 12: Strain: Basic Principles	frames 1298-1300, 1308-16, 1376-84, 1408-17, 1432-37, 1487-92